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ABSTRACT

Acknowledging the importance of sight to the writing process, the paper elucidates the processes of vision related to the composing process. In the opening section the physics of light and vision, optic neuroanatomy, and cortical responses to visual stimuli are explained. Next, theories of vision and data mapping are examined and their implications for composition theory and pedagogy are discussed. The remainder of the paper focuses on the role of vision in the composing process, considering: (1) the relationships between writing and other kinds of language, (2) writing dysfunction, and (3) visual defects causing visual language mode deficits. Vision pathologies that contribute to writing deficiencies are then explained. These include: right homonymous hemianopia, aphasia, dyslexia, simultanagnosia, a specific lesion near the angular gyrus, delayed maturation in the parieto-occipital regions, and other neurological disorders. Composition teachers often encounter but do not recognize students whose writing impairments are caused by congenital brain malformation. Therefore, it is suggested that medical histories of all basic writing students might help distinguish which students are deficient in writing skills for educational reasons and which are neurologically impaired. (JL)

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The Physiology of Vision and the Process of Writing

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When I consider how my light is spent,
Ere half my days, in this dark world and wide,
And that one Talent which is death to hide,
Lodg'd with me useless . . .

So wrote John Milton in 1652 after his eyesight failed him completely (Hughes 1957, p. 168). The importance of sight to the writing process is indisputable; sight is so indispensable to the writing process that no congenitally blind person has ever become a writer of note. That sight is critical to pre-writing, writing, and revision has been well documented by Janet Emig (1978, pp. 63-67) and others. Donald Murray (1968; 1978) sees vision as important enough to refer to the stages of the writing process as preVISION, VISION and reVISION (1978, pp. 86-87). This paper is an attempt to elucidate the processes of vision as related to the composing process: the physics of light and vision, optic neuroanatomy, cortical responses to visual stimuli, and the correlations of vision and language necessary to communicate in the writing mode. We hope this multidisciplinary discourse is, in part, an answer to Donald Graves' (1981) recent call for a marriage of research disciplines to determine what students do when they write (pp. 204-205).

Electromagnetic radiation (light) in different wavelengths passes through the atmosphere after being reflected from the sheet of paper the writer composes on and is focused by the crystalline lens of the human eye onto the retina, inverted from reality. The retinal

photoreceptors, called rods and cones, are stimulated by quanta of electromagnetic radiation (photons) ranging from 400 to 700 nanometers in length. To see letters on a page means that some photons striking the letters are absorbed by the writing medium (ink or graphite) and other repelled while the photons striking the white around the letters are nearly all reflected, focusing a discernable electromagnetic pattern on the retina. The stimulated photoreceptors of the retina excite others electrically, thus sharing stimuli with one another. (Peele 1961; Neisser 1968; Boynton 1980; Gregory 1978).

The stimulated photoreceptors convert the light energy into electrical impulses to be conveyed along the optic nerves (about a million neurons in each cerebral hemisphere) via the superior colliculus (Barlow 1980; Schiller, et al 1980), perhaps with the aid of octopamine as a neurotransmitter, as Battelle (1980) demonstrated is the case with horseshoe crabs (Limulus Polyphemus). Other researchers, Leibovic and Sabah (1969) for example, believe that some visual processing synapses are neither chemical or electrical, particularly in the horizontal cells of the retina, whose bulbs send and receive signals through the exchange of potassium ions (pp. 273-292). Whatever the transfer system is it seems clear that some visual functions have two parallel channels: visually controlled saccadic eye movements (Schiller, et al 1980); perception (Dimond 1972, p. 43); luminance contours have one system and other perceptions

have another (Dick 1976, pp. 225-268). Though the role of the superior colliculus in vision has been historically underestimated, it is believed by some to be the "principal parallel pathway . . . with its direct connection from retinal ganglion cells" (Barlow 1980, p. 144).

To sort out neuroanatomic visual processes, perhaps a discussion of the gross anatomy of the human visual pathways is in order. We begin with the retina.

Retina is a term derived from Latin (rete, meaning "a net") and traceable to an Indo-European base meaning "loose, separate". The portion of the eye in the rear of the eyeball probably got its name from the net-like appearance of the blood vessels covering it (Gregory 1978, p. 60). The incoming pattern of light strikes the retina, a thin layer of cells thought to be an outgrowth of brain tissue which convert the light energy into electro-chemical impulses understandable by the nervous system (Gregory 1978, pp. 44, 60; Boynton 1980, pp. 48-54; Neisser 1968, pp. 204-214; Peele 1961, pp. 474-479). The rods and cones of the retina are the primary light-senstive cells and number in the millions in each eye (Peele 1961, p. 475; Gregory 1978, p. 63), each with as many as 40 million photoreceptor molecules because a single photon of light contains so little energy that the likelihood of a single photon exciting a single photoreceptor molecule is practically nil (Boynton 1980, p. 53). The cones and rods are connected to the ganglion cells via bipolar cells (Peele 1961, p. 477; Gregory 1978, p. 62). The optic

nerves, made up of the axons of millions of ganglion cells cross at the optic chiasm, channelling visual information from the left visual field to the right cerebral hemisphere and vice versa (Glickstein and Gibson 1976, pp. 90-98), then form the optic tract leading to the lateral geniculate bodies near the thalamus, where they divide into upper and lower visual quadrants known as the optic radiations (Whitaker 1971, p. 68). From there the signals proceed through the respective hemispheric cortices to the appropriate visual cortex in the occipital lobes.

In spite of the division of the optic tracts into left and right cerebral hemispheric pathways, there is little evidence of complete lateralization of vision because the splenium of the corpus callosum transfers visual data between the hemispheres for a variety of purposes (Whitaker 1971, pp. 70-71; Jaynes 1977, pp. 113-114; Dimond 1972, pp. 40-45). Dimond says each hemisphere has its own independent visual system, connected via the corpus callosum. This mass of fibers is so adept at transferring visual information that normal transfer of visual information has been found in patients with only a thin layer of fibers left intact after commissurotomy (Greenblatt, et al 1980, pp. 567-571). Visual language modes can be diminished or depleted by complete commissurotomy, however, because the visual data from the left visual field is not transferred from the right cerebral hemisphere to the left hemispheric angular gyrus (Goodglass and Kaplan 1972, p. 78; Greenblatt

1973, 1976). Further evidence for strong lateralization of visual language functions comes from studies of 20 patients with occipital lobe lesions, abnormal EEGs, and homonymous visual field loss (Streletz, et al 1981). David Crystal (1980) reports that right homonymous hemianopia is one of the most common visual defects encountered in language pathology because of its association with left hemispheric damage to speech areas (p. 85). Others report that language-specific visual patterns are lateralized while non-language-specific visual patterns are not (Dingwall and Whitaker 1978, pp. 230-231).

Each hemisphere's visual cortex is connected to a visual association area in that cerebral hemisphere. The left and right visual association cortices are connected and communicate with one another via the splenium of the corpus callosum. The visual data from the left visual field and the data from the right visual field are combined and coordinated for reading and writing in the visual association cortex of the left cerebral hemisphere and passed on to the angular gyrus and then on to a functionally triangular system not unlike a three-way conference telephone hookup, Wernike's area, Broca's area, and Heshl's gyrus (Geschwind 1972).

Contrary to 17th and 18th Century theories of vision, we do not see light, nor do we see the image projected by the lens onto the retina (Neisser 1968, pp. 204-214), but the image is interpreted by the neurons and that interpretation begins before the signal from the rods and cones reaches the ganglion (Hubel and Wiesel, 1979, p. 87),

possibly performed by the horizontal cells, amacrine cells, and bipolar cells of several types (Peele 1961, pp. 477-479). Apparently, further interpretation is made with each synapse along the optic pathway, so when the visual signal reaches the visual cortex of either cerebral hemisphere, a highly sophisticated interpretation of the visual image is ready for processing by the primary visual cortex of the occipital lobe. This area is also known as Brodmann's area 17 or the striate cortex, and forms the banks of the calcarine fissure (Peele 1961, p. 486).

Horace Barlow (1980) has hypothesized that, far from being a simple signal-detection process, the interpretation process of the data includes a highly refined version of the retinal image, a series of statistical analysis, and some perceptual integration of the data presented to the cortex from the visual pathways (pp. 146-163). If so, it follows that, in reading, "as the subject's exposure to any given stimulus increases, there is a point at which the stimulus can be preprocessed prior to a conscious awareness" (Dunn-Rankin 1978, pp. 122-130). The kind of preprocessing guesses the reader makes based on experience and context may explain a reader's inability to perceive ambiguity (Roberts 1973, pp. 34-54) and may account for the writer's failure to notice and correct some of the surface details of a composition simply because he sees what he intended to write, and not what he actually wrote. Having the student read aloud what he wrote (Hartwell 1980, p. 69) is a way to slow down the automatic

preprocessor just enough to allow the student to recognize that he may not have written what he intended, particularly plural endings for nouns and verbs, and past tense endings, which are often omitted during writing and not corrected during self-editing even though the writer uses the endings correctly when he is speaking. For good discussions of the role of saccadic eye movements and scanning in gathering visual information and preprocessing guessing during the composing processes of encoding, checking, and re-encoding, see Jacobson and Dodwell 1979, Bahill and Stark 1979, Bahill, et al 1980, Dunn-Rankin 1978, Haber 1970, Spooner, et al 1980, Iacono and Lykken 1981, Bridgeman and Palca 1980, and Myerson 1974.

Some researchers argue for the logarithmic mapping of retinal images on the visual cortex in visual illusion (Schwartz 1980b) and perception (Schwartz 1980a), that mapping made possible by the structure of the visual cortex, a system of elaborately architectured ocular-dominance columns (Hubel and Wiesel 1979). Others opt for a multiple-systems approach to brain organization with sensory projection systems grouped as one (Thompson 1980, pp. 176-181) or a statistical decision theory to explain how the visual cortex organizes and interprets visual data (Barlow 1980, pp. 146-163). Some see visual information processing as a form of indirect realism that presents to the brain a mediated version of the real world (Turvey 1978, p. 100), a view consistent with Terry Winograd's (1980) "domain of cognitive processes", that regularities are not in the world

or in linguistic structures but in the cognitive structures and processes generated as a person or machine interprets the world and linguistic structures (pp. 229-230). For that reason some see reading as a blending of information encoded by the author and information the reader already has, making reading a process that is not primirily visual (Smith 1975, p. 353), but one which involves serial and parallel retrieval of stored information (Seamon 1974, pp. 188-192) combined with the context-specific new information from the text (Olson 1977, p. 277; Roberts 1973, pp. 55-62). Other research indicates that little visual information is processed serially; "there is much parallel processing of information in the visual system" (Ratliff 1980, p. 126). Visual processes, then, are appositional, spatial, and parallel (Bogen 1977, pp. 138-140).

Still others, Marcel Kinsbourne (1980) in particular, are very critical of the "hard scientists'" attempt to localize function so strictly and the behaviorists' unwavering allegiance to outmoded paradigms: "we cannot afford to let our empirical advances much outstrip our theoretical models because our theoretical models constrain the range of questions we ask. So we continually need to refine and reformulate these models" (p. 45). Kinsbourne's newest model, a behavioral approach to mapping, employs what he terms the "functional cerebral distance principle." This principle is that actions and learning with loci of programming at close proximities in terms of highly connected neurons are functionally closer than

activities and learning with loci of programming at greater distances, measured in terms of fewer synaptic connections (pp. 46-47). He demonstrated his hypothesis during experiments using subsequent task performance (priming effects) and dual task performance (concurrent effects). Based on his and others' experiments, Kinsbourne would make a topography of behavior stated in terms of "(a)is nearer to (b) than it is to (c); (c) is nearer to (b) than it is to (a)". With such a procedure, he rather optimistically says, "it is likely that we will have an informative map of behavioral cerebral space long before the neurophysiologists acquire the technological skill required to elucidate the underlying neuronal hardware" (p. 49).

Kinsbourne's model has some interesting applications to composition theory, if only because of the interrelatedness of the language areas of the brain. Copying words and sentences from an external source to paper could be performed with little conscious attending to the task because of the proximity of the programming loci for reading and writing. Taking dictation is only moderately more attention-requiring because of the still relatively close proximity of the centers of mental activity involved. But writing the names of familiar people whose pictures are presented is more difficult because the neural mechanisms for face recognition and for encoding in print are not so closely related synaptically as copying or encoding dictated information, primarily because face recognition

is a function of the right hemisphere and the verbal or written naming mechanism left hemispheric (Carey 1978, p. 201; Bogen 1977, pp. 138-140). This does not mean, however, that programming loci in contralateral cerebral hemispheres are necessarily more distant functionally than different programming loci in the ipsilateral cerebral hemisphere. Mirror image limbs, for example, have closer functional cerebral space than do ipsilateral limbs (Kinsbourne 1980, p. 47). Nor does it mean that lateralization is material-specific, a point with pedagogical implications for teaching writing: "subject matter may be less important than its method of presentation. Thus, right hemisphere participations would involve more laboratory and field experience at the expense of lectures and seminars" (Bogen 1977, p. 148), e.g., to teach writing is to have the students write, rather than to have them listen to a lecture which allows them to only learn <u>about</u> writing - and some of that incorrectly (Hartwell 1981, p. 17). The same is true for students of second languages, who must learn to speak the new language by practicing their skills in field experience, not by studying lessons in a book (Roberts 1974, 1975, 1976, 1979). Though language is essentially left hemispheric, the integration of encoding and decoding in the visual mode requires the involvement of both hemispheres (Hecaen and Marcie 1974, p. 346), and practical experiences help achieve it.

If "writing is a thinking process" (D'Angelo 1977, p. ix), and if it "encodes language at a much more abstract level than does the

spoken system" (Myerson 1974, p. 61), and if it is evolution in microcosm, "a movement from an undifferentiated whole to a differentiated whole" (D'Angelo 1978, p. 79), then the acquisition of writing must be more difficult than the acquisition of speech. Indeed, all of these must be true, for writing began about 3,000 BC (Jaynes 1977, p. 68), centuries after the genesis of human speech, and proceeded "from pictures of visual events to symbols of phonetic events" (p. 176), and for some cultures is independent of immediate external reference, evidence that different writing skills are needed for different intellectual outcomes (Scribner and Cole 1978, p. 460). Just how visual-graphic codes represent phonetic codes in some cultures and how they relate to experience semantically in others is currently under investigation, along with how we respond to other visual images (Gombrich 1972). Some rate the symbol as the center and foundation of any society (White 1949); others go on to say not only that symbols are the center and foundation of society, but that certain symbols, texts, and not others, utterances, have produced Western culture (Olson 1977, p. 278). If that is the case, vision is critical not only to mobility, but also as a vehicle for reading and writing, tasks essential to "make it" in a Western culture.

Now that we have discussed visual processes in general, the remainder of this paper focuses on the role of vision in the composing process. Such a discussion necessitates some consideration of (1) the relationships between writing and other kinds of language,

(2) writing dysfunction, and (3) visual defects causing visual language mode deficits. We begin with visual defects other than myopia (nearsightedness) and hypermetropia (farsightedness) and work backwards.

It is probable that all localization theories of human language were arrived at inductively, as Hugh Buckingham says (1979, pp. 20-25), so we use the same approach to a discussion of vision and language - we generalize about the nature of healthy vision from specific cases of vision pathologies. One reason we take this approach is that the research makes clear that it is a reasonable approach: "Evidence from aphasia supports the concept that the neurological basis of reading includes the auditory comprehension system, in addition to structures which provide an association between the auditory and visual processes" (Goodglass and Kaplan 1972, p. 9). If evidence from aphasia gives us insight to language localization, and it certainly does (Geschwind 1972, 1974, 1979; Luria 1970, 1973; Goodglass and Blumstein 1973; Whitaker and Whitaker 1976; Lenneberg and Lenneberg 1975), then vision pathology should provide some insights to deficits of the visual language mode.

One of the most common visual defects encountered in language pathology is right homonymous hemianopia because of its association with left hemispheric damage to speech (Crystal 1980, p. 85). It was documented as early as 1864 by John Hughlings Jackson, a British neurologist whose work has had profound effect on the localizationist

school (Greenblatt 1977, pp. 412-415). Right homonymous hemianopia is a pathological state caused by a lesion in the left calcarine fissure or in the left optic radiation and may cause spelling and reading difficulties (Espir and Rose 1976, pp. 12, 24). Various visual field defects caused by lesions in the occipital lobes (calcarine fissure) or at various points along the optic pathways are illustrated in Figure 2. Naturally, deficits other than those illustrated occur, including visual association area defects such as apperceptive agnosia (Heilman 1978, pp. 162-165).

Writing deficits produced by congenitally deaf persons have been analyzed by computer and some of their errors corrected by the "thinking machine" (Parkhurst and MacEachron 1980, pp. 493-504). Actually, the computer-corrected texts were analyzed, which is more an analysis of computer-corrected texts than of student-generated work. At any rate, as I reported earlier (Roberts 1972), though the computer is being used in more sophisticated ways each year, it is useful only as an aid to teaching, and should be limited in use for correcting student papers, for it is incompassionate and unforgiving; man has not only compassion and the ability to forgive errors, but also the power to encourage students, traits indispensable to teachers of writing (Ajuriaguerra and Auzias 1975, p. 326).

Of the relationships between writing and other language modalities, Goodglass and Kaplan (1972) assert that writing may be autonomous from speech at the one-word level, but vast evidence indicates

that writing is built on speech with three types of writing associations: (1) the transfer of sounds into motor sequences for letters, following phonemic rules, (2) the "recall of syllables and short words as complete graphic sequences, bolstered by a visual model of word configurations", and (3) the "availability of oral spelling as a guide to writing" (p. 11); that writing letters is as important to writing as morphemes are to speaking (p. 10); and that normal reading is based on prior mastery of auditory language (p. 9). Egon Weigl (1975) says that though the writing system is distinct from speech, the written language syntax and lexicon are dependent on spoken language, so "competence in oral language is an integral part of written language" (pp. 384-385), and that written language requires a chain of interacting functions: recoding between inner speech and graphomotoric skills, feedback through both auditory and optic modes, syntactic rules, and the grapheme-phoneme correspondence rules. Even so, with reading and writing practice, oral language involvement is reduced (p. 387).

Of the grapheme-phoneme correspondence rules, Weigl and Bierwisch (1973) indicated that separate, independent graphemic structures are possible, but in need of empirical verification (pp. 18-19); Luria (1973) said graphemes are dependent on phonemes (p. 140); the "rules" are without a one-to-one correspondence, but work in clusters (Weigl 1975, p. 384); Lecours (1975) said the written code is superimposed on the oral code, and learning to read means the

child will establish associations between visual signs and acoustic signs which already have meaning for him and those visual signs, or symbols, become linked with kinaesthetic patterns in the muscles of the dominant hand (pp. 132-133); and visual errors may predominate when reading is not controlled by the grapheme-phoneme correspondence rules (Marshall and Newcombe 1977, p. 277). It is easy to see that the grapheme-phoneme correspondence rules are subject to debate for some time to come though the evidence is in favor of their existence.

Copying letters, according to Lecours, is the written correlate of echolalia in speech development. But the associations are not direct because children too young can't learn to write even though they have good motor coordination of arms, hands and fingers - a function of motor, psychomotor, and praxic organization (Ajuriaguerra and Auzias 1975, pp. 314-315) - because the association of visual signs with events is not direct, but requires a secondary set of associations. To link "a new set of visual signs to a learned set of auditory signs that are already associated with objects and events of which they have become symbols" cannot be achieved before a certain stage in brain maturation has been reached (Lecours, pp. 133-134).

The broader conception of aphasia takes writing impairment, dysgraphia, as part of its domain, but not intelligence or poor vision, as Goodglass and Kaplan report:

> Aphasia refers to the disturbance of any or all of the skills, associations, and habits of speech or written language, produced by injury to certain brain areas which are specialized for these functions. Disturbances . . . due to paralysis or incoordination of the musculature of speech or writing or to poor vision or hearing or to severe intellectual impairment are not, by themselves, aphasic (1972, p. 5).

Aphasia also includes amusia, which involves either musical alexia or musical agraphia, or both. Patients sometimes exhibit aphasia without amusia (Geschwind 1972; Luria 1970), aphasia with amusia (Zangwill 1975), or amusia without aphasia (Brust 1980). Brust has found, "musical reading and writing involve more heterogenous symbols than ordinary reading and writing of words" (p. 383), a position in agreement with hemisphere dominance theories. He reports his findings to be consistent with the literature on aphasia, alexia, and agraphia (p. 387). Some cases of agraphia without aphasia have been reported and explained as caused by a lesion in the handedness-dominant hemisphere that destroys the engrams for the complex motor activities in writing (Heilman, et al 1973). The engrams for writing, the most complex of all language modes, may be lost temporarily or permanently due to lesion (Goodglass and Kaplan 1972, p. 10). Other composition-related brain dysfunctions include dyslexia, an impairment of reading letters or words (Espir and Rose 1976, p. 24), simultanagnosia, a visual word-form recognition impairment (Warrington and Shallice 1980), pure word-blindness

without hemni-optic defect (Greenblatt 1973, 1976, 1977), and constructional apraxia, dysgraphias not resulting from specific language-area defects (Espir and Rose, p. 23) sometimes classified as various handwriting difficulties: motor disorganizations, somatospatial disorders, behavior disorders, or a combination (Ajuriaguerra and Auzias 1975, pp. 324-326).

Some writing disorders involving vision may be caused by a specific lesion near the angular gyrus, delayed maturation in the parieto-occipital regions, disturbed Gestalt functions, or lack of cerebral dominance (Espir and Rose 1976, p. 37). Lack of cerebral dominance is an interesting phenomenon often resulting in both writing and reading dysfunction. Normally, the right visual field has superiority in assessing the visual form of linguistic visual material (Levy and Reid 1976, p. 338). In a study of 20 dyslexics from 7 to 11 years of age at the Eye Institute of New Jersey, Leisman and Ashkenazi (1980) tested the hypothesis that lack of a left visual field dominance for spatial perception necessary for word and letter recognition may suggest "bilateral representation of spatial perception and processing in dyslexia" (p. 158). The subjects had good visual acuity (20/30 or better), a mean I.Q. score of over 100, no ocular pathology, nc mental retardation, and no other neurologic signs. Yet each was retarded more than two years in reading. The control group of 20 subjects of like age demonstrated similar vision, I.Q. scores, mental and neurological conditions, but each read at

grade level. EEG recordings of left parieto-occipital lobes were made and analyzed by computer. The differences in EEG activities and in computerized tomography (CT scans) indicate that the dyslexics' cerebral hemispheres had less sharing of information than found in normals, leading to the conclusion that the right hemisphere in the dyslexics was more autonomous in respect to visual language stimuli, perhaps even equal to the left (p. 163).

Espir and Rose (1976) devote several chapters to the causes of aphasia. The prognosis, they report, is poorer with older patients than with younger (p. 54), so by the time an aphasic reaches college age, his or her chances of full recovery are diminished. The teacher of composition, often faced with writing impaired students, seldom encounters writing dysfunction caused by brain traumas brought on by cardio-vascular accident (stroke), intracranial tumors, cerebral abscesses, diseases, or brain injuries. What the composition teacher sometimes encounters - and fails to recognize because of lack of background data - are students whose writing impairments are caused by congenital brain malformations. An aetiology of congenital brain malformations includes both environmental and genetic causes, as outlined by Espir and Rose (pp. 85-86):

> Environmental causes acting on the fetus via the mother:
> 1) Dietary - lack of protein, vitamin A, riboflavin, folic acid, or thiamine
> 2) Hormonal deficiency - pituitary, thyroid, or pancreas
> 3) Drugs - thalidomide, cortisone, antibiotics, nitrogen mustard, and anticonvulsants

4) Physical agents - radiation, hypoxia, hyperthermia
5) Infections - syphilis, rubella, toxoplasmosis

Genetic causes:
1) Chromosome mutations (affecting many systems)
2) Gene mutations (affecting single systems)

Many of these affect writing via the visual system through the visual association areas, the optic pathways, or the vision.

Writing samples of congenitally neurologically impaired subjects who speak normally but write aberrantly have been studied and found to be more like writing samples of aphasics than undereducated persons (Lawrence 1979). "A form of agraphia (more properly termed developmental written dyssyntaxia) occurs in individuals who have no evidence of cortical lesions, but who do have some form of neurological impairment, apparently acquired at birth or during early childhood" (p. 253). Her subjects appeared to have never fully developed writing skills, as opposed to those who have lost their ability to write, and they had abnormal births, suggesting congenital or post-natal neurological impairment (pp. 253-254). The subjects were referred to the Writing Clinic at Southern Illinois University at Edwardsville because they were able to use verbal language "normally" (except for articulation errors), but performed poorly on written work. Lawrence's investigation results suggested to her that graphic linguistic skills were arrested before they were fully

developed, and that the parieto-occipital regions may have suffered the congenital malformation (p. 261). Since the students were found to have suffered from mild congenital encephalopathy, perhaps the medical histories of all basic writing students should be considered as part of normal writing skills diagnosis to determine which students are deficient in writing skills for educational reasons and which are neurologically impaired. Composition teachers might then be in a better position to deal with the task of eliminating writing dysfunction.

Barbara von Eckardt Klein (1978) is one of a growing number of researchers calling for an interdisciplinary approach to "the neural realization of the language-responsible cognitive structure in human beings" (p. 27, 66). Marcel Kinsbourne (1980) accuses the so-called "hard scientists" (neurophysiologists, neurochemists, molecular biologists, organic chemists, theoretical physicists, and mathematicians are all on his hit list) of not knowing "beans about how mental functions are organized in the brain" (p. 49). Rhetoricians and teachers are crying for some hard data to support a workable, goal-oriented pedagogy that promises some success in teaching students to write well. I, for one, am willing to wed neurophysiology to behavioral psychology, if necessary, to improve the stance of writing as process rather than product (Perron 1978). I propose that this paper and an earlier one in neurolinguistics (Roberts 1980) indicate that a courtship, if not a betrothal and wedding, is in the offing.

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